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DEVELOPMENT OF OPTIMUM EXPLOSIVE TRAINS

AN INVESTIGATION CONCERNING STAB SENSITIVITY VERSUS LOADING DENSITY OF SOME INITIATING COMPOUNDS

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FEBRUARY 1955

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An Investigation Concerning Stab Sensitivity Versus Loading Density of Some Initiating Compounds

by

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February 1955

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OBJECT

To study the variation of the stab sensitivity of a few initiating compounds when the loading pressure is increased and all other parameters are held constant.

SUMMARY

This report describes the early results obtained in a study of the variation of stab sensitivity versus consolidation pressure for a number of primary explosives. Standard and new types of initiator compounds were included in this study in which the maximum consolidation pressure used was 80,000 psi. Each compound was found to have a characteristic stab sensitivity versus consolidation pressure relation. In all cases the increase of pressure resulted in an increased stab sensitivity. Although the effect of humidity was not controlled, the lack of control was evident in only one case. The results suggest the possible applicability of certain of the compounds for end-item use.

RECOMMENDATIONS

It is recommended that this study be continued, that the effect of controlled humidity variation on stab sensitivity be studied, that a precise method for easily measuring output energy be devised, that higher loading pressures be studied, that variation in pin velocity versus stab sensitivity be determined, that the controlled variation of particle size be studied, that the significant differences exhibited by the various types of lead azide be investigated, that the effect of initiation on deflagration leading to detonation be followed, and new compounds be investigated as they are prepared.

INTRODUCTION:

1. This is the fifth progress report to be issued under Project TA3-5101, "The Development of Optimum Explosive Trains." (Refs 1, 2, 3). The purpose of this particular type of study is to explore the accepted methods for initiating primary explosives as applied to the newer compounds which are being synthesized. It seems reasonable to assume that the characteristics of new sensitive materials when examined by accepted methods should exhibit differences even under these semi-quantitative conditions from the few, more well-known primary explosives. This study is designed to obtain information not heretofore available which may lead to a more fundamental study of the materials in question and, hence, to a better understanding of the differences exhibited. In addition, the study will provide needed stab sensitivity data on the newer materials which are becoming available.

2. A review of the available literature (Refs 4 thru 8) indicates that although many reports have been published for impact sensitivity, relatively few concerning stab sensitivity exist. In general, these investigations were performed using standard ordnance items and not solely for the purpose of obtaining fundamental information as is reported here.

3. Each of the experimental compounds selected for this investigation was representative of a salt type compound, i.e., hexamine chromic perchlorate is an inorganic coordination compound, potassium dinitrobenzfuroxan (KDNBF) is the salt of a fuzed ring system with metal to carbon attachment, and copper chloro-tetrazole is the salt of a halogenated tetrazole ring with metal to nitrogen attachment. The two British lead azides and mercury fulminate were included purely for reference purposes.

4. It was intended at first, in conjunction with this investigation, to also study the effect of loading pressure variations on the output of these materials. However, since the only readily available method for obtaining output measurements was the lead disc method depending upon visual inspection, it was considered insufficiently accurate for this study.

DISCUSSION OF RESULTS:

5. For this investigation, six compounds were chosen: two standard materials and four experimental compounds. The

two standard materials were mercury fulminate and British Service lead azide and the experimental compounds were hexamine chromic perchlorate, potassium dinitrobenzfuroxan, copper chlorotetrazole and British lead azide R. D. 1333. The results are summarized in Table 1. Figures I thru VI show graphically the sensitivity range versus loading pressure for each compound. Figure VIII shows the pressure density relation of each of these materials. A composite graph for comparison purposes is given in Figure VII. Photomicrographs showing the actual materials used are included at the end of the report in Figures IX and X.

6. The results obtained for KDNBF show an increase in sensitivity with increases in pressure and a marked narrowing of the firing range at the higher loading pressures. Copper chlorotetrazole, although extremely sensitive even at low pressures still increases in sensitivity with an increase of loading pressure.

7. Hexamine chromic perchlorate increased in sensitivity until an apparent maximum point was reached. However, it may be well to note here that the stab sensitivity of the compound appeared to be affected by humidity. In order to prevent erratic results it was found necessary to store this material in a desiccator prior to firing. The assumption was substantiated by loading 25 detonators at 60,000 psi and storing them in a humid atmosphere of 90% RH for 3 hours prior to firing. The compound exhibited a sensitivity of 28 inch-ounces as compared to 12 inch-ounces for the material dried over calcium sulfate. It is apparent that conditions of controlled humidity will be required in future work of this nature.

8. Dextrinated lead azide was first selected as a standard, but due to its complete lack of sensitivity to stab initiation it was deemed desirable to substitute British Service lead azide. All attempts to initiate British Service azide at pressure loadings less than 40,000 psi resulted in failure. However, detonation was obtained at 40,000 psi and all higher pressures. The behavior of British Service lead acide was most striking. Not only was the shape of the curve for stab sensitivity for their material somewhat different from the curves for other materials tested, but the degree of stab sensitivity was also very much less (Figures IV and VII). British lead azide R. D. 1333 also exhibited a relatively low degree of stab sensitivity, but was more sensitive than British Service lead azide (Figures VI and VII). Just which crystal or physical property is

exerting this effect has not yet been deduced.

9. The percentage of partial initiations as well as the stab sensitivity results for mercury fulminate are given in Figure V. Note the similar asymptotic behavior to that exhibited by hexamine chromic perchlorate. The sensitivity of mercury fulminate increased with loading pressure up to 40,000 psi, but remained fairly constant at the still higher pressures. Since this compound is so closely associated with the term "Dead Press", the "positives" were closely scrutinized and it was found that partial explosions were experienced at 20,000 psi. Further, the percentage of partials grew larger as the loading pressure was increased, as shown on the graph Figure V until practically 100% partials resulted when a pressure of 80,000 psi was used. It would appear from this data that "Dead Press" is associated with output rather than input phenomena.

10. It seems quite apparent that under these experimental conditions, each primary explosive molecule is characterized by its own stab sensitivity versus loading pressure or density relation. The amount and type of data obtained so far, does not permit a conclusion as to the principal factor which is operative; however, it does seem that considerations dealing with absolute crystal density do not lead to satisfying arguments and speculation on the rate of change of density with loading pressure do not offer very fruitful methods of approach. On the other hand, consideration of the crystals themselves does seem to offer a fruitful approach. Crystal size, crystal size distribution, strength and hardness of the crystals seem reasonable factors to be operative in this phenomena.

11. In addition to the above considerations, it is evident too that an answer is required on the effect, if any, of this variation in stab sensitivity on the duration of deflagration leading to detonation (Ref 11). This in turn will require fairly precise measurement of the detonation velocity of each material under the several experimental conditions which have been obtained in the work herein reported. No matter whether these or other approaches are followed, considerably more effort is required to provide a definitive conclusion on these phenomena.

EXPERIMENTAL PROCEDURE:

12. The most accurate means available were used for all measurements. Weighings were made on an analytical balance

and a micrometer was used to obtain dimensions for density calculations. All pressings were made on a Kent air press which uses a lever arm-weight system to control loading pressure.

13. Previous experience has shown that it is impractical to use weighed amounts of material when press loading. Therefore, the exact weight was determined by weighing the cylinder before and after loading. The material was pressed into aluminum sleeves of 0.186 inches I.D. and of sufficient length to be longer than the expected column of explosives. Cylinders, rather than detonators, were used so as to remove the possibility of an air cushion between the detonator and the lead disc. The material was loaded in small increments with a dwell time of approximately 5 seconds. Standard stab discs of 0.002 inches thickness were pressed on top of each column of explosive. All samples were fired with a standard Drop Test machine. The firing pins were tested under magnification to assure uniform point dimensions.

14. The accuracy of the ball strike was checked at each height. It may be well to note here that it was necessary to modify our Drop ~t machine prior to starting this investigation. It was found that the lesser weight balls (1.5 ounce) when dropped from low heights showed a scattered pattern. It was determined that the ball either rolled off one side of the magnet core or was spun by magnetic flux. This trouble was eliminated by installing a brass plate with a centered hole directly under the core.

15. In order to obtain a reasonable sample size, one that would give an accurate result and not be too burdensome, 60 units were loaded at each pressure.

16. Output results were obtained by visual inspection only of the lead discs. Dents in or punctures of the discs were taken as an indication of detonation of the column of initiator.

17. The 50% points reported were calculated using the method described in References 9 and 10.

18. Density figures were calculated from measurements taken with a toolmaker's micrometer. The possibility of expansion after loading was investigated and found to be inconsequential. Loading density curves are shown in Figure VIII.

19. During the course of all these loadings, extreme care was taken to avoid any sharp impact of the press on the explosives. It is felt that this caution was the reason for our not experiencing a single "blow" with any of these sensitive materials.

ACKNOWLEDGEMENT:

20. Discussions with Dr. J. V. R. Kaufman which were helpful in the initiation and pursuance of this work is acknowledged as is the formalization of this program by Mr. J. E. Abel.

REFERENCES:

1. R. J. Gaughran, J. E. Abel, A. C. Forsyth - Development of Optimum Explosive Trains, Picatinny Arsenal Memorandum Report No. 43, 30 September 1953.

2. R. J. Gaughran, J. P. Picard - Preparation of Colloidal Lead Styphnate, Picatinny Arsenal Technical Report No. 2077, October 1954.

3. J. E. Abel, Pfc. J. Alster, A. C. Forsyth, H. J. Jackson, C. L. Pataky - Development of a New Ignition Temperature Apparatus, Picatinny Arsenal Technical Report No. 2093, November 1954.

4. L. D. Hampton - Density of a Pressed Explosive as a Function of Loading Pressure, N.O.L.M. 10765.

5. A. R. Ubbelohde and P. Woodward - The Effects of Compression on the Sensitiveness of Initiators, A.R.D. No. 402/45.

6. Capp et al - The Sensitiveness of Explosives, Royal Society of London Phil. Trans. V241, No. 831, P197-296, 1948.

7. J. V. Graff and R. T. Skelton - The Relationship Between Sensitivity and Loading Pressures for Stab Type Priming Mixtures, NAVORD Report No. 2110.

8. Trials to Determine the Comparitive Sensitivity of "A" Mixture Detonators when Fired (A) Ball and Striker, (B) Free Falling Striker, Great Britain. (Received in U. S. 30 March 1950).

REFERENCES (contd)

9. H. P. Davis - Comparison of the Probit Method and the Bruceton Method as Applied to Sensitivity Data, N.O.L.M. 9910.

10. Statistical Research Group, Princeton University - Statistical Analyses for a New Procedure in Sensitivity Experiments, dated July 1954.

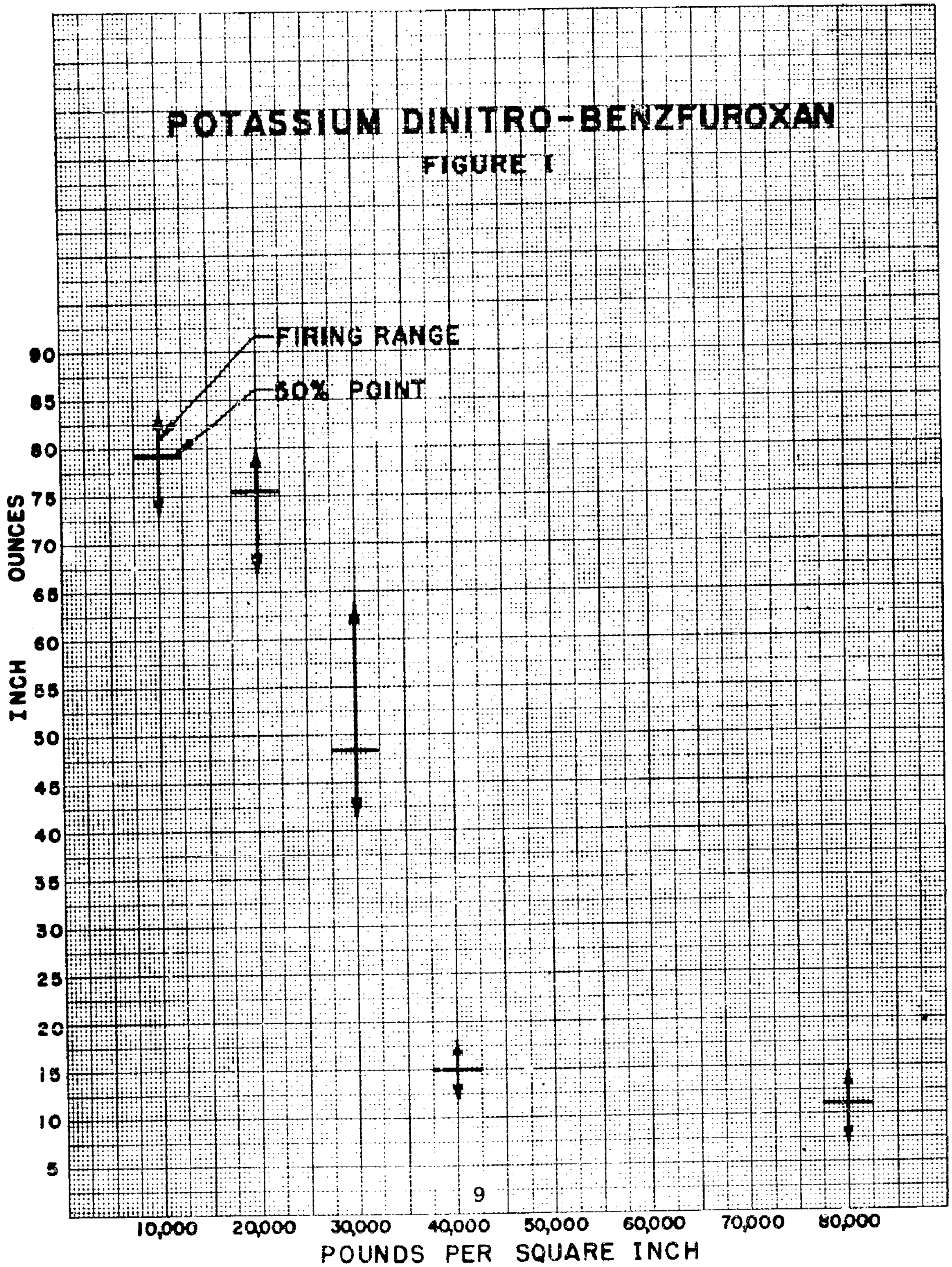
11. F. P. Bowden, A. D. Yoffe - Initiation and Growth of Explosion in Liquids and Solids, Cambridge University Press, 1952.

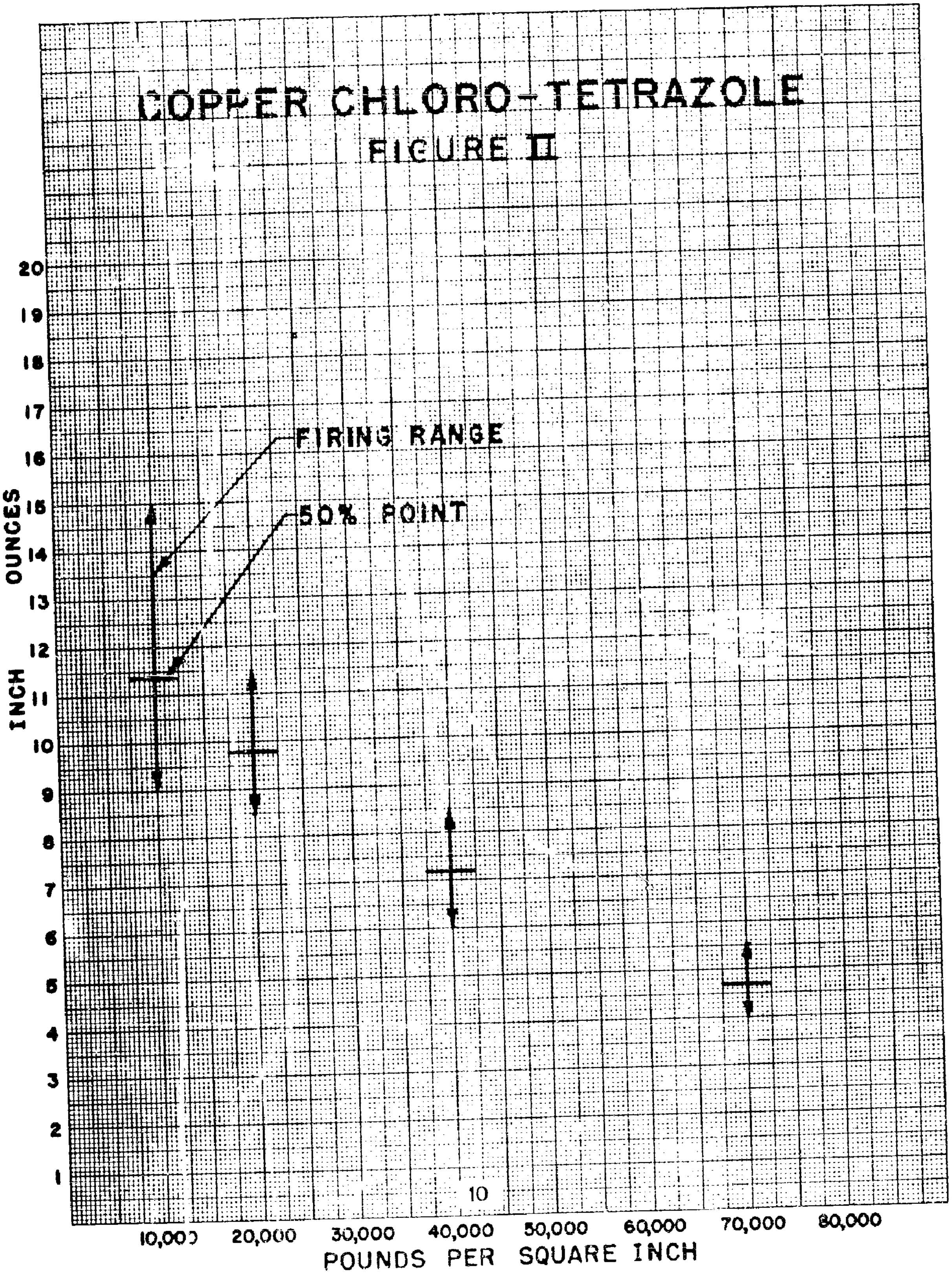
INCLOSURE:

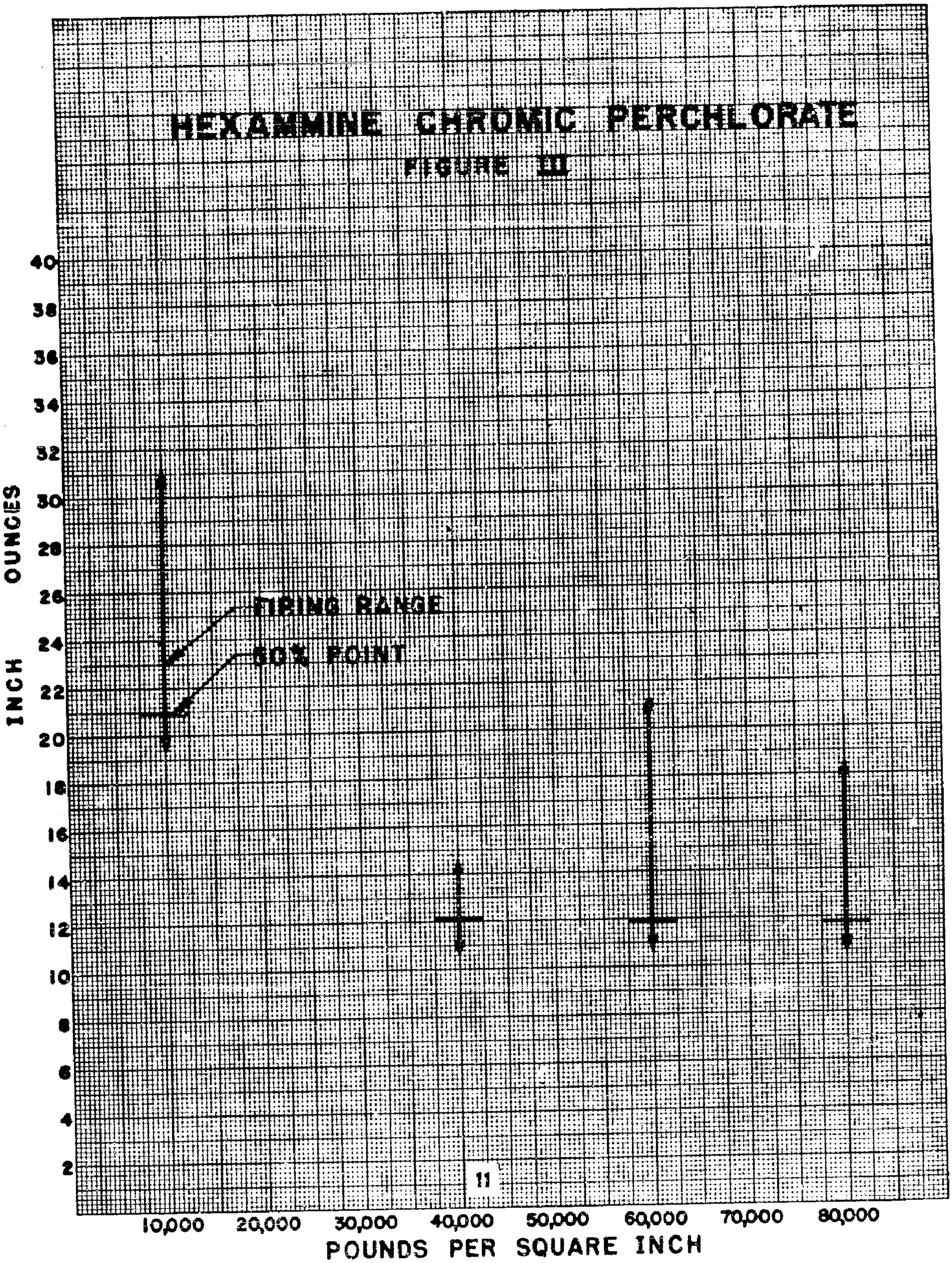
1. Table 1
2. Figures I thru X

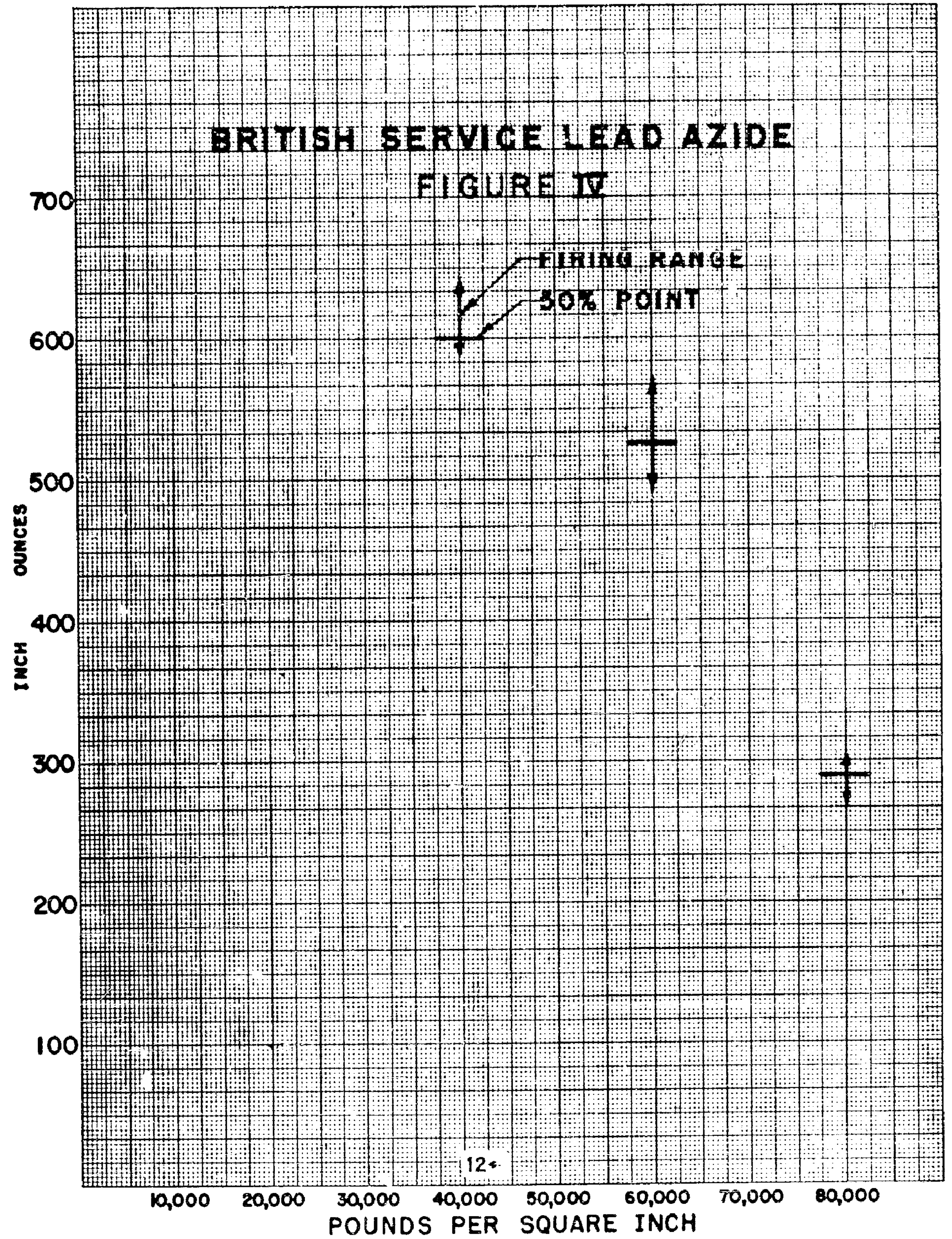
TABLE 1

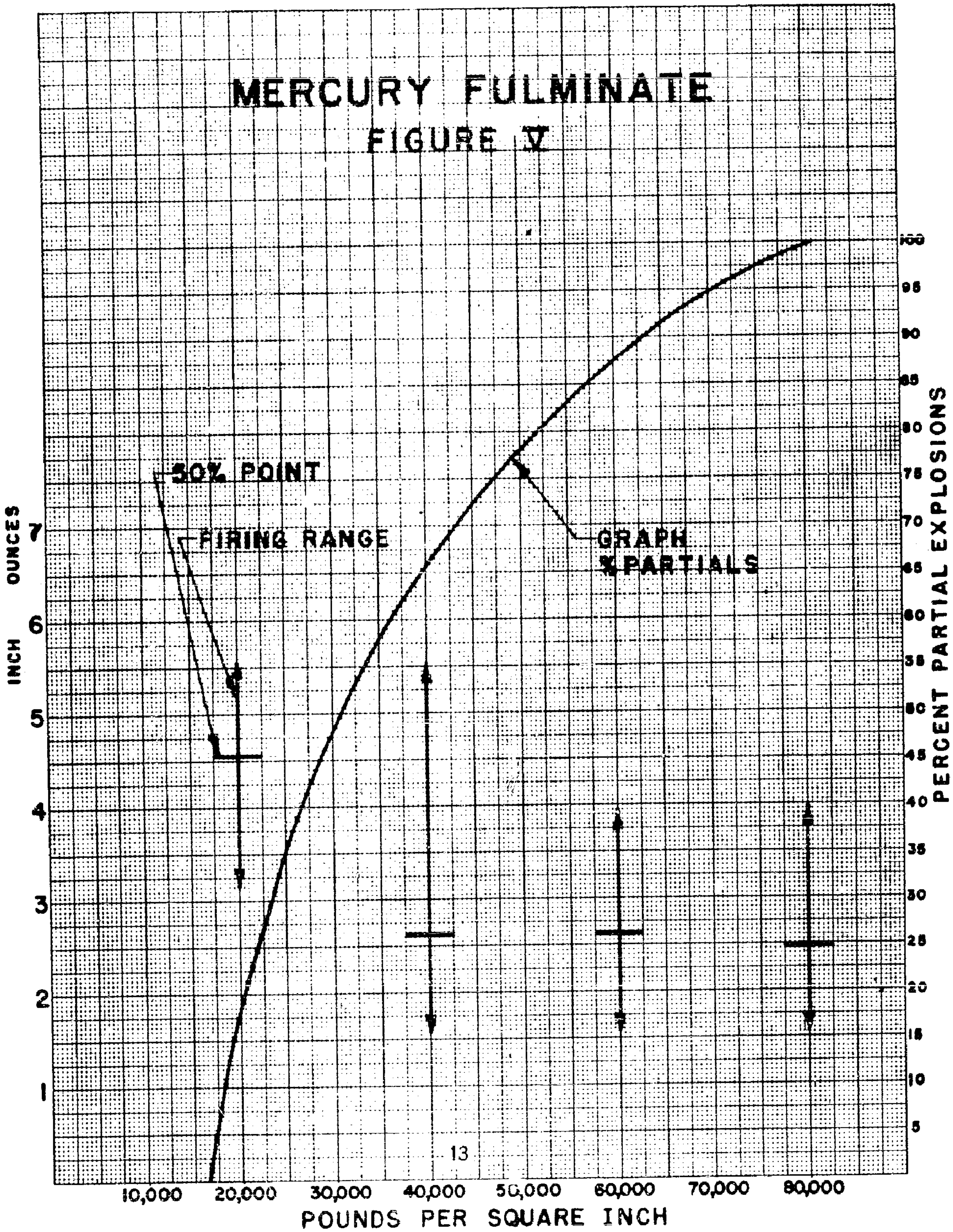
Compound	Type of Compound	Loading Pressure psi	0 % Firing Point (Observed) Inch-ounces	50 % Firing Point (Calculated) Inch-ounces	100 % Firing Point (Observed) Inch-ounces)	Weight of Material Grams	Density of Material Gms/cc
Potassium Dinitro-benzfuroxan	Salt of a fuzed ring system	10,000	73.00	79.28	84.00	.2525	1.63
		20,000	66.00	75.48	83.00	.2525	1.77
		30,000	42.00	48.36	64.00	.2525	1.81
		40,000	12.00	15.00	18.00	.2525	1.86
		55,000	11.00	17.08	21.00	.2525	1.93
		80,000	7.00	10.80	14.00	.2525	1.98
Copper chloro tetrazole	Salt of a halo-genated tetrazole ring	10,000	9.00	11.42	15.00	.2210	1.49
		20,000	8.50	9.78	11.50	.2210	1.63
		40,000	6.00	7.15	8.50	.2210	1.74
		70,000	4.00	4.69	5.50	.2210	1.86
Hexamine chromic perchlorate	Inorganic coordination compound	10,000	19.40	20.81	31.04	.2500	1.66
		40,000	10.67	12.18	14.55	.2500	1.88
		60,000	10.67	11.89	21.34	.2500	1.92
		80,000	10.67	11.74	18.43	.2500	2.07
Mercury Fulminate	Organic salt	20,000	3.16	4.25	5.53	.5000	3.91
		40,000	1.58	2.62	5.53	.5000	4.26
		60,000	1.58	2.62	3.95	.5000	4.32
		80,000	1.58	2.49	3.95	.5000	4.50
Brit sh Service Lead azide	Inorganic salt	40,000	584.00	599.00	640.00	.5000	4.13
		60,000	496.00	529.60	568.00	.5000	4.31
		80,000	268.00	294.40	316.00	.5000	4.39
Lead Azide R.D. 1333	Inorganic salt	20,000	143.50	167.50	180.20	.4000	3.49
		40,000	30.00	54.20	70.00	.4000	3.79
		60,000	28.00	32.80	34.00	.4000	3.98
		80,000	12.00	22.00	28.00	.4000	4.14

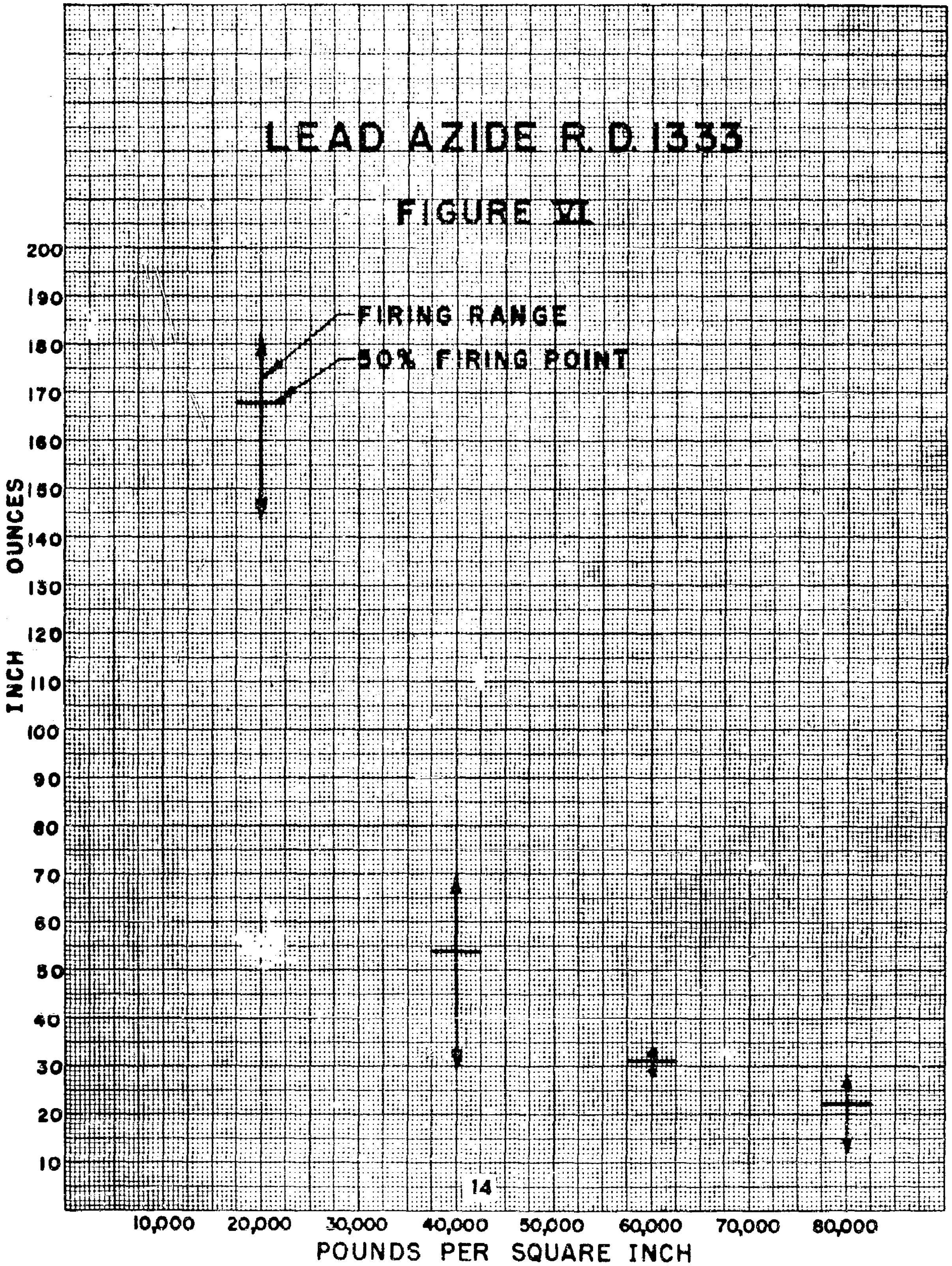

POTASSIUM DINITRO-BENZFUROXAN
FIGURE I
FIRING RANGE
50% POINT
INCH OUNCES
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH

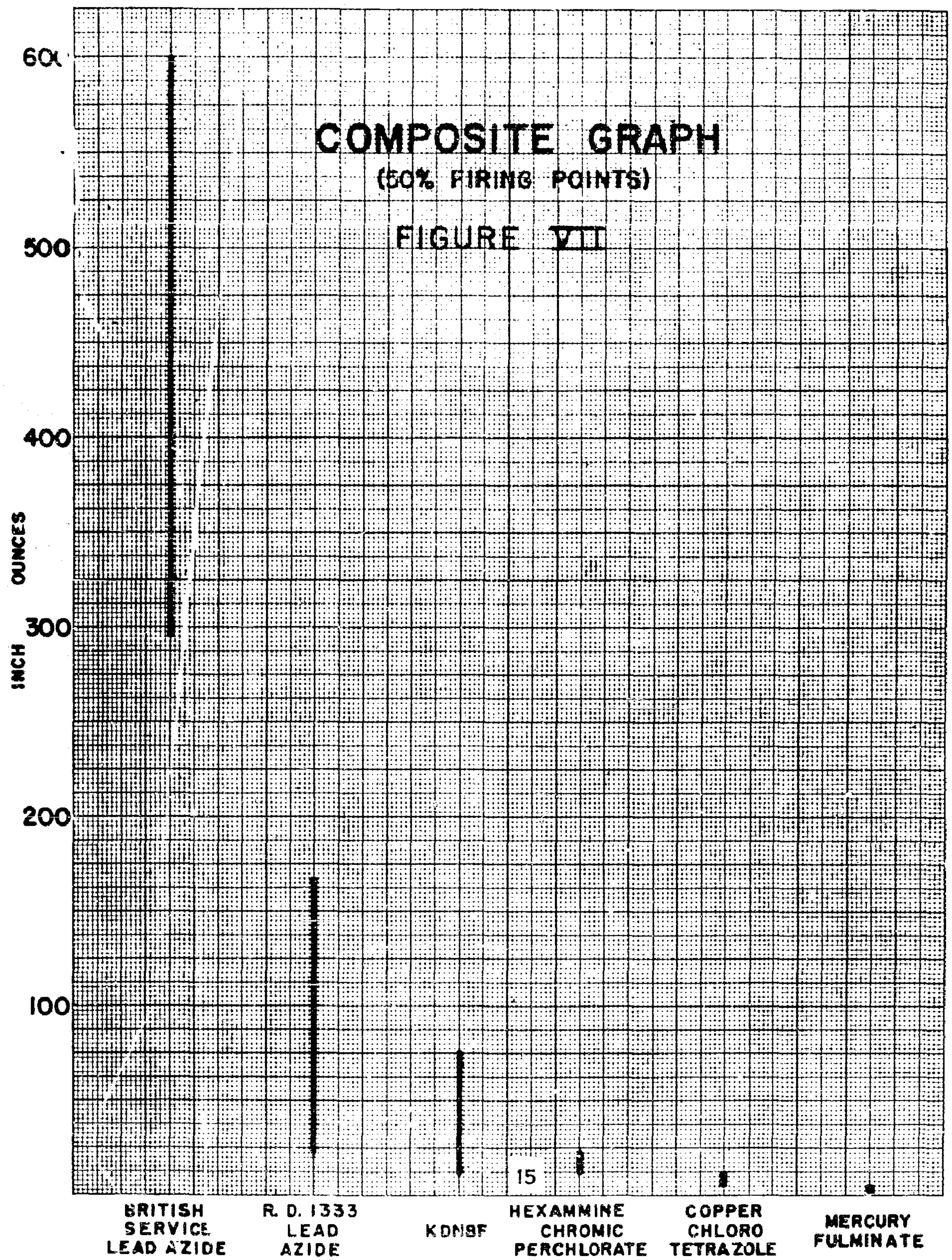

COPPER CHLORO-TETRAZOLE
FIGURE II
FIRING RANGE
50% POINT
OUNCES
INCH
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH


HEXAMMINE CHROMIC PERCHLORATE
FIGURE III
FIRING RANGE
50% POINT
INCH OUNCES
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH


BRITISH SERVICE LEAD AZIDE
FIGURE IV
FIRING RANGE
50% POINT
700
600
500
400
300
200
100
INCH OUNCES
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH

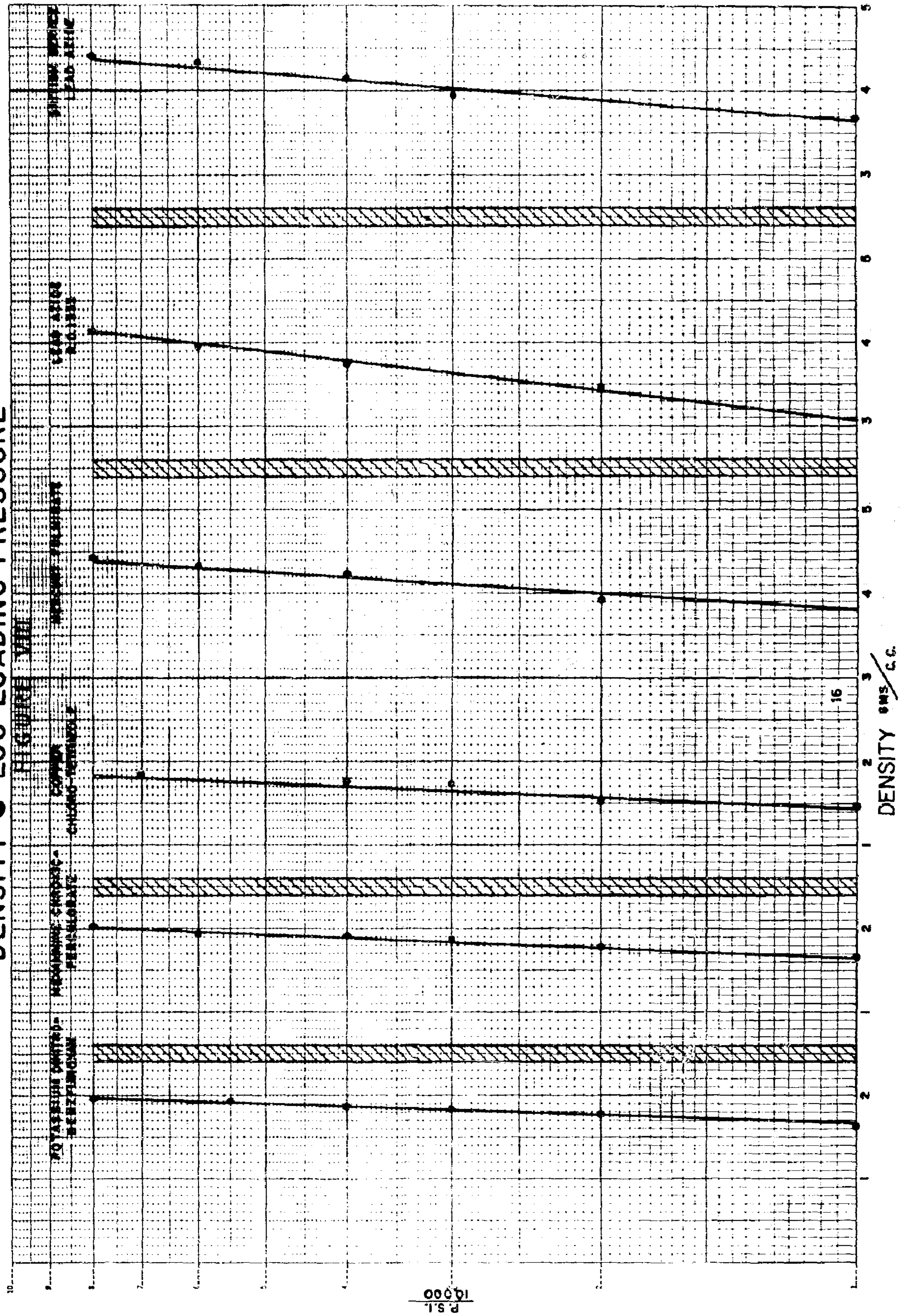

MERCURY FULMINATE
FIGURE V
50% POINT
FIRING RANGE
GRAPH
% PARTIALS
INCH OUNCES
1
2
3
4
5
6
7
PERCENT PARTIAL EXPLOSIONS
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH

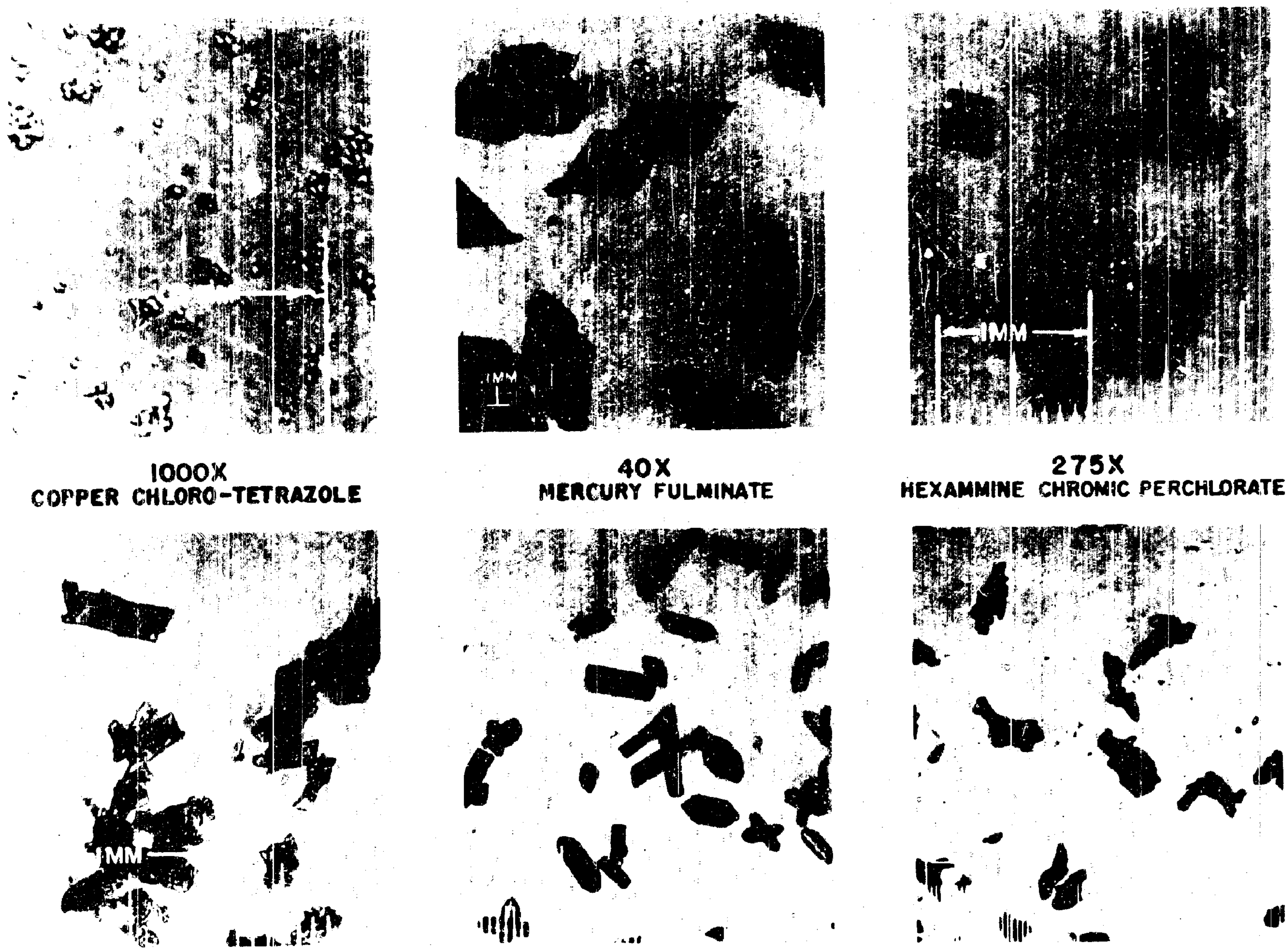

LEAD AZIDE R.D. 1333
FIGURE VI
FIRING RANGE
50% FIRING POINT
INCH OUNCES
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
POUNDS PER SQUARE INCH


COMPOSITE GRAPH
(50% FIRING POINTS)
FIGURE VII
INCH OUNCES
600
500
400
300
200
100
BRITISH SERVICE LEAD AZIDE
R. D. 1333 LEAD AZIDE
KDNBF
HEXAMMINE CHROMIC PERCHLORATE
COPPER CHLORO TETRAZOLE
MERCURY FULMINATE

DENSITY vs LOG LOADING PRESSURE

FIGURE VIII





1000X
COPPER CHLORO-TETRAZOLE

40X
MERCURY FULMINATE

275X
HEXAMMINE CHROMIC PERCHLORATE

275X
POTASSIUM DINITRO BENZFUROXAN

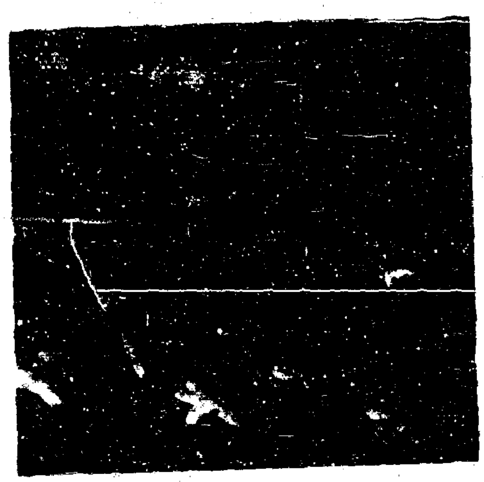
150X
BRITISH SERVICE LEAD AZIDE

90X
LEAD AZIDE R.D.1333

PHOTOMICROGRAPHS OF COMPOUNDS USED FOR STAB SENSITIVITY TESTS
FIGURE IX

LEAD AZIDE R.D.1333

FIGURE X



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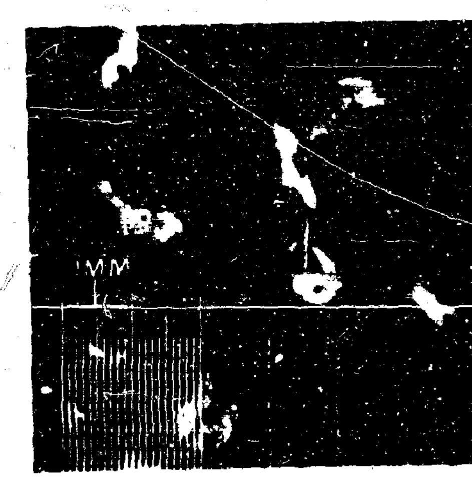

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